Using Soil Amendments to Improve Riparian Plant Survival in Arid and Semi-arid Landscapes

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INTRODUCTION

The widespread loss and degradation of riparian areas in the arid and semi-arid western United States has led to an increased interest in revegetation efforts aimed at restoring physical and ecological functions, such as streambank stabilization, wildlife habitat, and water quality protection (Briggs 1995) (Figure 1). However, successfully establishing riparian plant communities that can provide desired functions can be extremely challenging in arid areas that are remote from water supplies. In addition, plant establishment can be difficult in arid regions since many stream and riparian areas are characterized by infertile or highly saline soils, very low rainfall, narrow planting windows, dynamic/erosive hydrologic patterns that often scour soils holding planted vegetation, and prolific non-native plant species that tend to dominate the plant community.

Figure 1. A riparian revegetation project along the Las Vegas Wash, NV, is being facilitated by the use of a soil amendment to improve plant survival

Revegetation efforts in arid riparian areas are frequently unsuccessful where irrigation is not possible (e.g., water rights often preclude water withdraw from streams and rivers), is cost-prohibitive, or where the water table occurs below the root zone of newly established vegetation. Lack of irrigation or lowered water tables can prevent establishment and survival of riparian plants (Briggs 1996). Under the best of conditions, plant mortality is often about 20 percent in arid areas, and during drought conditions or where soil fertility is poor, mortality can often exceed 80 percent (e.g., Briggs 1992, 1995).

Recently, several soil amendments have been developed to enhance plant survival in arid environments by holding and slowly delivering water near the root zone of planted vegetation. This technical note describes these new technologies and discusses investigations designed by the U.S. Army Engineer Research and Development Center, Vicksburg, MS, to field test their efficacy.

SOIL AMENDMENTS

DRiWATER®. One amendment having potential utility to riparian restoration in arid regions

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is DRiWATER®[1] (Figure 2), which is a non-toxic patented time-release "solid" water product consisting of water (98 percent) and food grade ingredients (2 percent cellulose and alum). Naturally occurring soil bacteria gradually break down the food grade ingredients to slowly release and provide a continuous source of water to plants. Capillary activity of the soil carries and maintains moisture throughout the root zone for up to 90 days (Figure 3). The product is available in two types of containers for revegetation efforts—quart-sized in a biodegradable cardboard container (for a single application), or with a PVC tube and 3-in.-diam quart Gel Pac for longer-term use. The amendment is subsequently applied every 30-90 days during the growing season until plant materials are established.

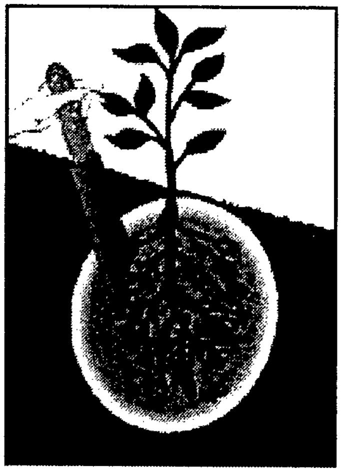

Figure 2. DRiWATER® is placed in a tube near the root zone to provide a continuous source of water

Figure 3. DRiWATER® Gel Pac and tube application to recently planted vegetation along the Las Vegas Wash, NV

To install the DRiWATER® amendment, follow normal protocols for excavating a planting hole to the proper depth for the plant. While backfilling, position the proper number of tubes (based on size of plant; see Table 1) in the hole and angle at approximately 45 degrees such that the bottom of the tube is placed in direct contact with the root mass and the top of the tube is slightly above ground level (Figure 3). When using multiple tubes, they should be spaced an equal distance around the plant. The hole should then be backfilled, and any soil, rock, or other debris that enters the tube should be removed. Each plant should be watered thoroughly through the tubes before applying DRiWATER® (water-stressed plants may not receive enough initial water from DRiWATER® to survive). The Gel Pac should then be opened, wetted with water, placed completely in the tube, and capped. For revegetation projects in areas with a relatively high water table, the single application quart container may be sufficient to allow roots to reach water. In more arid areas or at sites with low water tables, the PVC tube with multiple DRiWATER® applications may be more appropriate. The number of applications of DRiWATER® needed for plants to become established, as well as the number of days between reapplications, is currently not well-documented. However, application rates will be affected by plant species, annual rainfall, frequency of inundation or rainfall during the growing season, mean temperature, soil type,

Table 1
Number of DRiWATER® Gel Pacs to Apply Based on Size of Plant

Container Size/Stem Diameter	Plant Height in.	Number of 1-Qt. Gel Pacs
Bare-root seedling	6-10	1
1 gal	10-18	2-4
5 gal	36	4-5
¾ in.	60	5-7
1 in.	72-84	6-8
1½ in.	96-108	9-11

[1] Use of trade names does not imply endorsement by the Federal Government.

elevation, wind conditions, and aspect of exposure (N, S, E, or W). If possible, providing some supplemental water at the time of reapplication may be desirable, but this may not always be feasible. Current field research efforts (see below) will attempt to answer such questions as length and number of applications for plants to become established, influence on plant survival, and cost-effectiveness.

Water-absorbent Polymers. Another potentially useful group of soil amendments are super-absorbent water retention polymers (Figure 4), also referred to as root watering crystals, planting gels, and water retention granules. These polyacrylamide-based granules were designed to absorb soil water up to 400 times their own weight. Water is held near the root zone and slowly released to plant roots over an extended period of time (i.e., several years). The polymers can be recharged with precipitation, irrigation, or hand watering. These products are sold in both fine- and medium-grade consistencies. Fine-grade product is mixed with water and bare-root seedling roots are dipped in the mixture just prior to planting. Medium-grade product typically is saturated and then mixed with the backfill soil or placed directly in the planting hole. Recommended mixture rates for a commonly used polymer called Terra-Sorb™ are provided in Table 2. Too much polymer material can cause the soil to over-swell and push planted vegetation out of the ground.

Figure 4. Water-absorbent polymers have potential utility as a soil amendment in riparian revegetation projects

Table 2
Amount of Medium-Grade Terra-Sorb™ (by Dry Volume) to Apply Based on Size of Plant[1]

Container Size/Stem Diameter	Volume of Terra-Sorb™
1 gal	½ oz.
3 gal	1 oz.
5 gal	1 ½ oz.
10 gal	2 ½ oz.
1 in.	2 ½ oz.
2 in.	4 oz.
3 in.	1 cup

[1] Note that it is desirable to saturate these amounts prior to application of product in planting hole.

Verschoor and Rethman (1992) studied the use of Terra-Sorb™ on an arid plant species in South Africa. Their results suggested that available water to plant roots was increased, especially under drought conditions in sandy soils. Increased available water led to an increase in aboveground plant biomass. Specht and Harvey-Jones (2000) obtained similar results with polyacrylamide gels on woody seedlings in arid areas of Australia. Terra-Sorb™ can potentially reduce transplant stress, increase initial growth and development, reduce watering needs, and reduce project costs.

DEMONSTRATION PROJECTS

Although soil amendments appear useful for establishing healthy vegetation by accelerating establishment time and improving survival, little scientific information is available to assess the effectiveness of these amendments under field conditions. Although several examples of successful projects using these amendments are available on corporate Websites, the success and effectiveness of amendments where irrigation and intense cultural practices are impractical has not been extensively studied in large-scale

controlled experiments. The Environmental Laboratory at the U.S. Army Engineer Research and Development Center currently has several demonstration projects in Arizona and Texas to determine the efficacy of soil amendments in establishing riparian plants in arid and semi-arid regions.

Salt River, Arizona. In June 2003, a demonstration project was initiated along a tributary to the Salt River on Salt River Pima-Maricopa Indian Community (SRPMIC) lands. The purpose of the project is to evaluate the survival of velvet mesquite (*Prosopis velutina*) (Figure 5) using various applications of Terra-Sorb™ and DRiWATER®. Six plots utilizing different treatments were established. The site will be monitored annually for survival and growth rates.

A second demonstration project similar in design to the SRPMIC site was established

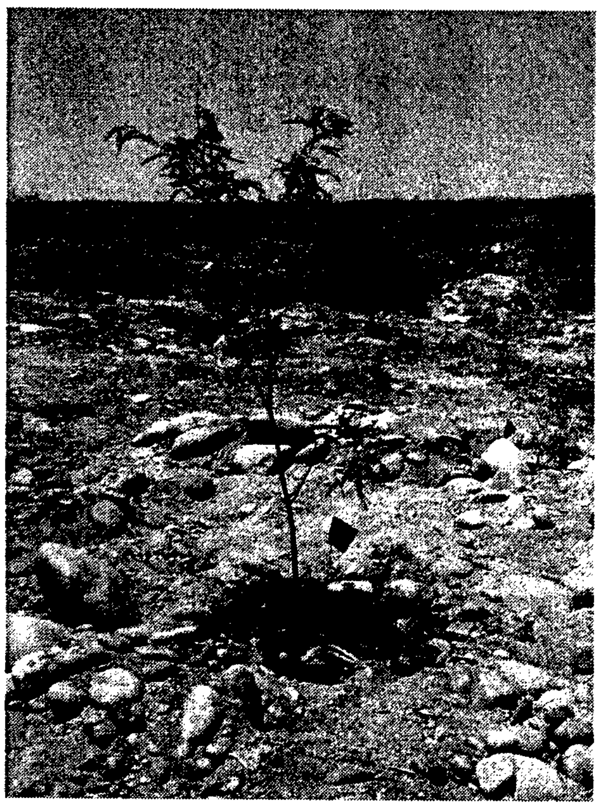

Figure 5. Velvet mesquite (*Prosopis velutina*) trees were planted with various soil amendment treatments along a tributary to the Salt River, AZ

along the Salt River in Phoenix as part of the Rio Salado project. This demonstration will be monitored concurrently with the SRPMIC project. A third demonstration in Phoenix is planned during 2004 for dormant-season installation using the same design and amendments on a wider variety of plant species.

Lewisville Lake Ecological Learning Area (LLELA), TX. In 2002, an experiment comparing various watering and fertilizing regimens was initiated on 1000 bare-root seedlings at LLELA. The three treatments included applications of either (1) mycorrhizal inoculants, (2) water-absorbent polymers, or (3) fertilizer tablets. Data on seedling survival will be collected in the fall for three consecutive years. Fall assessment has been chosen in order to determine survival after the traditional summer drought. A second demonstration is planned on LLELA during winter 2004 and will incorporate DRiWATER® into the design.

Dyess Air Force Base, TX. A site on Dyess Air Force Base will also be used to test the efficacy and relative costs of using soil amendments and traditional drip-irrigation as part of a large-scale riparian revegetation effort using a variety of native woody riparian plants. Approximately 500 seedlings and containerized plants will be planted during March 2004. Results of a subsequent assessment after the first growing season will be used to make decisions on how to plant an additional 4 miles of riparian area on the installation during 2005 and 2006.

SUMMARY

Riparian revegetation projects in arid areas are often hampered by difficulties in plant establishment and poor plant survival. Lack of irrigation or lowered water tables can preclude establishment and survival of riparian plants. Techniques to increase flexibility and reduce plant mortality are needed, and additional benefits may be accrued if those techniques reduce or eliminate irrigation requirements or lengthen time of planting

windows. Using water-retaining soil amendments in riparian revegetation projects may provide a solution to problems associated with water delivery to plants. Potential for cost savings may arise from reduced labor and equipment costs, reduced water waste, and by providing a reliable water source for plant establishment. This method may also lend itself to sites having difficult terrain, upland reforestation, dune restoration, and mine land reclamation. A future ERDC technical note will provide results of research currently being conducted on the efficacy of soil amendments described in this note to improve establishment and survival of woody riparian vegetation. Additional research questions being addressed include the number of applications and length of time that DRiWATER® is necessary for plants to become established, and cost-effectiveness of soil amendments versus traditional irrigation methods.

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